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## (54) VECTOR CONTROLLED BLDC MOTOR DRIVING A RANGE HOOD AND CORRESPONDING CONTROL METHOD

VEKTOR GESTEUERTER BÜRSTENLOSER GLEICHSTROM MOTOR FÜR EINE DUNSTABZUGSHAUBE UND ENTSPRECHENDE ANSTEUERUNG

MOTEUR À COURANT CONTINU SANS BALAI POUR UNE HOTTE D’EXTRACTION CONTRÔLE VECTORIELLE ET MÉTHODE

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**Description**

BACKGROUND

**1. Field of the Invention**

**[0001]** The present invention relates to a brushless direct current (BLDC) motor, and more particularly, to a method of controlling a constant current of a BLDC motor capable of significantly increasing airflow relative to a pressure by receiving a constant current of a BLDC motor as feedback and controlling a rotational speed of the BLDC motor, and a controller of a BLDC motor using the same. Furthermore, it relates to a BLDC motor being driven by such a controller or by such a method and to a range hood comprising such BDLC motor.

**2. Discussion of Related Art**

**[0002]** Generally, a cooking table on which a heating device such as an electric heater or a gas range for cooking such as boiling or baking through an application of high-temperature heat to food is disposed is provided in a kitchen.

**[0003]** In this case, in a process of heating food to be cooked which is heated by a high temperature of the heating device disposed on the cooking table, contaminants such as smoke, odor, oil vapor, and the like are generated. Such contaminants may float due to the heat and diffuse throughout a kitchen or an entire room, and the diffused contaminants provide an unpleasant odor which causes aversion. Specifically, in a closed kitchen, these contaminants become factors that degrade the concentration of workers and harm the health of the workers.

**[0004]** Accordingly, a range hood for discharging contaminants such as smoke, odor, oil vapor, and the like which arc generated when food is cooked to the outdoors is provided in a kitchen.

**[0005]** Such a range hood may include a main body which forms an exterior of the range hood, a fan which sucks air into the main body and generates airflow for discharging the air to the outside, a filter which is installed in the main body and filters the air sucked into the main body, and a pipe or duct which forms a path for discharging the air sucked into the main body through the filter to the outside.

**[0006]** Since a predetermined power is supplied to an alternating current (AC) motor used in a conventional fan for each airflow mode, it is impossible to control a rotational speed of a fan. Conversely, a brushless direct current (BLDC) motor has an advantage in that a rotational speed of a fan may be controlled.

**[0007]** In the case of a conventional BLDC motor, initially, the motor was controlled by a method of controlling a rotational speed at a constant speed for each airflow mode. However, in the case of a rotational speed control method (i.e., a so-called revolutions per minute (RPM) control method), when there is a flow resistance (a load) in an outlet of a hood, airflow generated in the hood is decreased even when the fan rotates at the same rotational speed.

**[0008]** Specifically, in the case of the RPM control method, airflow generated by the BLDC motor may be greater than airflow generated by an AC motor when there is little flow resistance in the outlet of the fan. However, when a flow resistance of a certain level or more is generated, use of the AC motor results in greater airflow (see FIG. 5).

**[0009]** In consideration of the above characteristics, by applying a method of controlling a fixed current in a BLDC motor, it is possible to control airflow to be the same as or greater than that of an AC motor even when high or low flow resistance is generated in an outlet of a fan. However, in this case, since there is no difference in efficiency of airflow generation between an AC motor and a BLDC motor (see FIG. 5) as the flow resistance in an outlet of a fan is increased, it is unnecessary to apply a BLDC motor which requires complicated control thereto.

**[0010]** Meanwhile, an airflow mode of a range hood is set to generate airflow intended by range hood designers. The airflow is determined in consideration of a structure of a main body, a fan, and a filter constituting a product. However, a structure of a duct behind the fan of the range hood may not be controlled by the designers of the range hood. Therefore, when an installation structure or environment of the range hood is changed (i.e., when the range hood is installed in another apartment or the like), the airflow intended by the designers is not generated in the airflow mode of the range hood installed in the corresponding environment and this may lead to a degradation of performance of the product.

**[0011]** Therefore, even when the installation environment of the range hood is changed, the BLDC motor should be controlled to generate the airflow intended by the designers so that the range hood may efficiently operate to meet the designed intention thereof. Also, these characteristics are not limited to the range hood.

**[0012]** CN 103 123 124 A discloses a high-efficiency gang control device of an extractor hood and a gas stove. The high-efficiency gang control device comprises an extractor hood and the gas stove and is characterized in that a gas stove control system and a gas stove human-machine interface are arranged on the gas stove, a step motor for controlling a fuel valve is arranged on each of a left fuel valve and a right fuel valve of the gas stove and is connected with the gas stove control system, a wireless transmitting module is arranged on the gas stove control system, an extractor hood control system and an extractor hood human-machine interface are arranged on the extractor hood, an extractor hood motor in the extractor hood is connected with the extractor hood control system, and a wireless receiving module corresponding to the wireless transmitting module is arranged on the extractor hood control system. The extractor hood control system acquires a firepower signal of the gas stove through the wireless modules and the rotating speed of the extractor hood motor is regulated according to the firepower signal of the gas stove.

## SUMMARY

**[0013]** The present invention is directed to a method of controlling a brushless direct current (BLDC) motor according to claim 1.

**[0014]** Further, the present invention is directed to a controller of a BLDC motor comprising a BLDC motor according to claim 9.

**[0015]** Further, the present invention is directed to a range hood according to claim 15.

**[0016]** The object is solved by the features of the independent claims. Preferred embodiments are given in the dependent claims.

**[0017]** According to the present invention, there is provided a a method of controlling a brushless direct current BLDC motor, the method comprising:comparing a constant current of a three-phase-to-two-phase converter of an output port of a BLDC motor to a reference current of a present air flow mode;as a result of the comparison, applying speed command to a rotational speed control unit; andcontrolling, by the rotational speed control unit, a speed of the BLDC motor according to the applied speed commands,wherein as the result of the comparison, applying an increase speed command to a rotational speed control unit when the constant current is lower than the reference current, applying a decrease speed command to the rotational speed control unit when the constant current is higher than the reference current, and maintaining and applying the same speed command to the rotational speed control unit when the constant current is the same as the reference current.

**[0018]** The reference current may have a preset value corresponding to each of multi-stage airflow modes.

**[0019]** The speed commands may be applied to the rotational speed control unit after present speed ($\omega_m$) of the BLDC motor is fed back thereto.

**[0020]** The rotational speed control unit may include a speed controller (11) and a current controller (12), the speed command may be applied to the speed controller, and the speed controller may apply a current command ($I^*_{qse}$) corresponding to the applied speed command to the current controller.

**[0021]** The current command may be applied to the current controller after the constant current of the output port of the BLDC motor is fed back thereto.

**[0022]** The method may further include, in a process of entering a higher speed airflow mode than a present airflow mode, obtaining an instant speed of the BLDC motor at a time point at which the constant current of the output port of the BLDC motor exceeds an entering reference current of a corresponding airflow mode, and applying the obtained instant speed to the rotational speed control unit as a speed command ($\omega^{**}_m$) and completing a process of entering the corresponding airflow mode.

**[0023]** The entering reference current may have a higher value than a preset reference current of the corresponding airflow mode.

**[0024]** The instant speed of the BLDC motor may be obtained using a sensorless method. According to another aspect of the present invention, there is provided a controller of a BLDC motor comprising a BLDC motor, and a rotational speed control unit including a speed controller configured to generate a current command for controlling a rotational speed of the BLDC motor,wherein the controller of a BLDC motor further comprises a constant current control unit configured to receive a constant current of the three-phase-to-two-phase converter of an output port of the BLDC motor as an input, to compare the constant current to a reference current, and to output a speed command to the rotational speed control unit, wherein the constant current control unit outputs an increase speed command when the constant current is lower than the reference current, outputs a decrease speed command when the constant current is higher than the reference current, and maintains and outputs the same speed command when the constant current is the same as the reference current.

**[0025]** A command in which a present speed ($\omega_m$) of the BLDC motor is fed back to the speed command output from the constant current control unit may be input to the speed controller.

**[0026]** The controller of the BLDC motor may further include a motor sensing unit (18) or motor sensor.

**[0027]** The motor sensing unit (18) is configured to receive a voltage and current of an input end of the BLDC motor (16) and a voltage and current of the output port thereof and output values of current rotational angular position ($\theta_m$) and rotational speed ($\omega_m$) of the BLDC motor, wherein the rotational speed output from the motor sensing unit may be fed back to the speed command output from the constant current control unit.

**[0028]** In a process of entering a higher speed airflow mode than a present airflow mode, the constant current control unit may obtain an instant speed of the BLDC motor at a time point at which the constant current of the output port of the BLDC motor exceeds an entering reference current of a corresponding airflow mode, apply the obtained instant speed to the rotational speed control unit as the speed command, and enter the corresponding airflow mode.

**[0029]** The entering reference current may have a higher value than a preset reference current of the corresponding airflow mode.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0030]** The above and other objects and advantages of the present invention will become more apparent to those of ordinary skill in the art by describing exemplary implementations thereof in detail with reference to the accompanying drawings, in which:

FIG. 1 is a control block diagram illustrating a brushless direct current (BLDC) motor rotational speed control algorithm;

FIG. 2 is a control block diagram illustrating a BLDC constant current constant control algorithm;

FIGS. 3 and 4 are flowcharts illustrating a process of controlling a BLDC motor; and

FIG. 5 is a graph illustrating experimental results illustrating a relationship between a static pressure and airflow in the cases of controlling rotational speed of a BLDC motor to be fixed, controlling current of a BLDC motor to be fixed, controlling airflow of a BLDC motor is fixed, and using an alternating current (AC) motor.

## DETAILED DESCRIPTION OF EXEMPLARY IMPLEMENTATIONS

**[0031]** Hereinafter, exemplary implementations of the present invention will be described in detail with reference to the accompanying drawings.

**[0032]** The present invention is not limited to the implementations to be disclosed but by the appendent claims. The implementations are provided in order to fully explain the present disclosure to those skilled in the art.

[Rotational Speed Control Unit]

**[0033]** FIG. 1 is a diagram illustrating a brushless direct current (BLDC) motor rotational speed control algorithm. Referring to FIG. 1, a rotational speed of a BLDC motor 16 is controlled by a rotational speed control unit 10. That is, the rotational speed control unit 10 controls the BLDC motor to rotate the BLDC motor at a desired speed. The rotational speed control unit 10 includes a speed controller 11 and a current controller 12. In some implementations, at least one of the speed controller 11 and/or the current controller 12 can be a proportional integral controller.

**[0034]** A value of a q-axis current command $I^*_{qse}$ corresponding to the rotational speed of the BLDC motor 16 is mapped in and/or provided to the rotational speed control unit 10. The current command is generated by a speed controller 11. The current command generated by the speed controller 11 is input to a current controller 12 after a value of a q-axis constant current $I_{qse}$ output from an output port of the BLDC motor 16 is fed back thereto. After a value of a d-axis constant current $I_{dse}$ output from the output port of the BLDC motor is fed back to a d-axis command current $I^*_{dse}$ having a value of 0, the d-axis command current $I^*_{dse}$ is also input to the current controller 12. The fed back signals $I_{dse}$ and $I_{qse}$ are subtracted from the d-axis command current $I^*_{dse}$ and the q-axis current command $I^*_{qse}$ correspondingly.

**[0035]** The current controller 12 receives the current commands, to which the constant currents are fed back, as inputs to generate a d-axis command voltage $V^*_{dse}$ and a q-axis command voltage $V^*_{qse}$, and the d-axis command voltage $V^*_{dse}$ and the q-axis command voltage $V^*_{qse}$ are input to a two-phase-to-three-phase converter 13.

**[0036]** The two-phase-to-three-phase converter 13 converts a two-phase command voltage into a three-phase command voltage and inputs the converted three-phase command voltage to a digital pulse width modulation (DPWM) control unit 14. The DPWM control unit 14 controls switching of an inverter 15 corresponding to the above input and controls the BLDC motor 16. A three-phase-to-two-phase converter 17 converts a three-phase voltage into a two-phase voltage and inputs the two phase voltage into a motor sensing unit 18 and/or provide the two-phase voltages or currents as fed back signal to current command signals.The motor sensing unit 18, which estimates a rotational angular position and rotational speed of a motor using a sensorless algorithm, compares a current and voltage detected in the BLDC motor to a current and voltage output from the current controller 12, and estimates and outputs a current rotational angular position $\theta_m$ and a current rotational speed $\omega_m$ of the motor.

**[0037]** The current rotational speed of the motor output from the motor sensing unit is continuously monitored, and thus the value of the q-axis current command $I^*_{qse}$ output from the speed controller 11 is determined by the current rotational speed of the motor.

[Constant Current Control Unit]

**[0038]** When a rotational speed of the BLDC motor 16 is controlled by only the above-described rotational speed control unit 10, a rotational speed of a motor which rotates a fan may be constantly maintained at a target rotational speed. However, when a flow resistance in an outlet of a duct or the like located behind the fan according to an installation environment of a range hood or the like is large, airflow generated by the fan is decreased even though the rotational speed of the motor is maintained (see ① of a pressure quantity (PQ) diagram in FIG. 5). That is, the fan rotates, but required airflow designed by designers is not generated.

**[0039]** In such a situation, although a rotational speed of the fan is maintained, a phenomenon in which the constant current of the BLDC motor is decreased occurs since work that the fan does to generate the airflow decreases. Therefore, in order to prevent the airflow from decreasing even when a discharge resistance increases, it is necessary to increase the rotational speed of the fan and increase work that the BLDC motor does to generate the airflow by controlling the BLDC motor so that the constant current does not decrease.

**[0040]** Accordingly, an example in which a constant current is controlled in a closed loop, that is, is feedback-controlled will be described.

**[0041]** FIG. 2 is a control block diagram illustrating a BLDC constant current constant control algorithm, and FIGS. 3 and 4 are flowcharts illustrating a process of starting a BLDC motor. In FIG. 2, in relation to FIG. 1, a BLDC motor includes the rotational speed control unit 10 of the BLDC motor illustrated in FIG. 1 and further includes a constant current control unit 20 which continuously receives a value of a constant current $I_{qse}$ of the BLDC motor 16 and outputs a rotational speed command $\omega^*_m$ of the BLDC motor to the rotational speed control unit 10 based on the value of the constant current $I_{qse}$. The constant current $I_{qse}$ is directly provided to the constant current control unit 20.

**[0042]** Compared to the case in which the rotational speed control unit 10 independently controls the BLDC motor 16 at a rotational speed designated according to a mapping value for each airflow mode, when the constant current control unit 20 controls the BLDC motor together with the rotational speed control unit 10, a rotational speed of the BLDC motor 16 is controlled so that a constant current of the BLDC motor 16 becomes constant. In the constant current control unit 20, a reference current required for each airflow mode is set. That is, it may be understood that a higher reference current is set for a higher airflow mode.

**[0043]** Referring to FIG. 2, a constant current controller 21 of the constant current control unit 20 compares a current constant current $I_{qse}$ of the BLDC motor to a reference current $I_{std}$ that is required for a corresponding airflow mode of multiple airflow modes for a fan. The constant current controller 21 outputs the rotational speed command $\omega^*_m$ to the speed controller 11 of the rotational speed control unit 10 according to the comparison result.

**[0044]** A present speed $\omega_m$ of the BLDC motor 16 is fed back to the speed command $\omega^*_m$ of the constant current controller 21, and the speed command $\omega^*_m$ of the constant current controller 21 is input to the speed controller 11 of the rotational speed control unit 10. The speed controller 11 controls the BLDC motor 16 so that the BLDC motor rotates based on the rotational speed input from the constant current controller 21.

**[0045]** Referring to a method of controlling a BLDC motor in detail with reference to FIGS. 2 and 4, a value of the constant current $I_{qse}$ of an output port of a BLDC motor is continuously provided to the constant current controller 21 of the constant current control unit 20. The constant current controller 21 compares the provided value of the constant current to the reference current $I_{std}$ of a corresponding airflow mode.

**[0046]** As a result of the comparison, when the constant current of the motor is the same as the reference current (i.e., when intended airflow is generated), the present speed command $\omega^*_m$ is constantly maintained, when the constant current is less than the reference current (i.e., when less than the intended airflow is generated), an increase speed command is output, and when the constant current exceeds the reference current (i.e., when more than the intended airflow is generated), a decrease speed command is output.

**[0047]** Also, the rotational speed control unit 10 controls the rotational speed of the BLDC motor based on the speed command. Even in the controlling process of the motor, the value of the constant current $I_{qse}$ of the output port of the BLDC motor is continuously provided to the constant current controller 21 of the constant current control unit 20 so that the feedback-control is continued.

**[0048]** Such a feedback-control method corresponds to a current variation control since a target rotational speed of the BLDC motor may be continuously changed to maintain the constant current. Effects of increasing the airflow according to the current variation control are illustrated in FIG. 5. That is, compared to the case in which the rotational speed of the BLDC motor is controlled by only the rotational speed control unit 10 (see ① of FIG. 5), when the current variation control for constantly maintaining the constant current is performed as in the present invention (see ③ of FIG. 5), it may be confirmed that a discharge resistance is increased, and thus the largest airflow is generated even when a static pressure increases.

**[0049]** It may be confirmed that, compared to the case in which the rotational speed of the BLDC motor is controlled by supplying a fixed current to the BLDC motor (see ② of FIG. 5), there is a better airflow generation effect. That is, a value of a current required to further increase the airflow may vary according to a static pressure. Since such a requirement may not be satisfied when the BLDC motor is controlled by a fixed current being supplied thereto, it may be understood that less than required airflow is generated. That is, a PQ diagram illustrated in ③ of FIG. 5 may be obtained when the constant current control unit 20 and the rotational speed control unit 10 are used together as described above.

**[0050]** Meanwhile, the reference current $I_{std}$ is preferably set to be a numerical range and not to be a certain value of a corresponding airflow mode. The reference range is preferably set so that a variation of the constant current in each airflow mode is minimized.

**[0051]** Although an example in which the motor sensing unitusing the sensorless algorithm is used is illustrated in the above-described implementations, the method of controlling a BLDC motor of the present invention may be applied even though various types of other motor sensing units such as an encoder and the like are applied.

[Airflow Mode Entering Process Control]

**[0052]** The airflow mode control described above relates to control after entering an airflow mode. However, when using a motor sensing unitusing a sensorless algorithm, the algorithm is significantly accurate after entering an airflow mode but may have a factor that is somewhat unstable during control in a process of entering the airflow mode. Specifically, when the airflow mode is changed in a direction in which airflow increases, there is a concern about a speed fluctuation when using the sensorless algorithm.

**[0053]** Accordingly, the airflow mode entering process control illustrated in FIG. 3 is additionally performed to remove the speed fluctuation phenomenon. First, when the airflow mode is changed by a user, a timer, or the like, whether a corresponding change command is for increasing or decreasing the airflow is determined. When the airflow mode is changed in a direction in which the airflow decreases, problems such as a speed fluctuation and the like do not occur, and thus the process enters the constant current control process (see FIG. 4) described above. That is, the speed of the BLDC motor is lowered by performing the constant current control described above based on the reference current $I_{std}$ corresponding to the lowered airflow mode.

**[0054]** Meanwhile, when the airflow mode is changed in the direction in which the airflow increases, the constant current controller 21 outputs a speed command corresponding to the changed reference current $I_{std}$ of the corresponding airflow mode or an entering reference current, which is set to be slightly higher than the reference current $I_{std}$ of the corresponding airflow mode, to increase the speed of the BLDC motor. Even in this process, the value of the constant current $I_{qse}$ of the BLDC motor is also continuously provided to the constant current controller 21.

**[0055]** When the airflow mode is changed in the direction in which the airflow increases, whether the constant current exceeds the entering reference current, which is set to be slightly higher than the reference current of the corresponding airflow mode, is determined. In a state in which the constant current is not yet more than the entering reference current, the control of the BLDC motor is continued to continuously increase the speed thereof.

**[0056]** As a result of the motor control through which the speed is increased, when the constant current of the output port of the motor exceeds the entering reference current, the constant current control unit 20 obtains a rotational speed of the BLDC motor at a time point at which the constant current exceeds the entering reference current. The constant current control unit 20 outputs the obtained rotational speed to the rotational speed control unit 10 as a temporary speed command $\omega^{**}_m$ for entering the airflow mode.

**[0057]** As a result of the control of the rotational speed control unit 10 based on the temporary speed command $\omega^{**}_m$ for entering the airflow mode, when it is determined that the instant speed of the BLDC motor exceeds the temporary speed command $\omega^{**}_m$ for entering the airflow mode, the entering of the airflow mode is finally completed. After the entering of the airflow mode is completed, the control illustrated in FIG. 4 is continued.

**[0058]** The control of the airflow mode entering process is because a speed fluctuation phenomenon in which the entering of the airflow mode is performed without any problem when the airflow mode is lowered, but the airflow mode does not stably reach the increased airflow mode when the airflow mode is increased. That is, in the above-described airflow mode entering process control, after the rotational speed of the BLDC motor is raised to a higher temporary airflow mode than a target airflow mode, the BLDC motor is controlled again in the target airflow mode (having a lower airflow than in the temporary airflow mode), and thus the speed fluctuation phenomenon may be addressed.

**[0059]** In the control method of a controller of a BLDC motor since a BLDC constant current constant control algorithm is used, airflow is hardly decreased even when there is a flow resistance in an outlet of a fan rotated by the BLDC motor.

**[0060]** Accordingly, even when the fan rotated by the BLDC motor is installed in an environment in which a flow resistance inevitably varies, a designed airflow can be generated.

**[0061]** Such a control method can be applied to all multi-stage airflow modes only by setting a reference current of each of the airflow modes and controlling a rotational speed to match the constant current of the BLDC motor to a corresponding reference current.

**[0062]** Also, since the control method of the present invention can prevent a speed fluctuation phenomenon (i.e., a so-called chattering phenomenon) which occurs during an airflow mode changing process, specifically, a speed increasing process, the BLDC motor can stably operate.

## Claims

1. A method of controlling a brushless direct current BLDC motor, the method comprising:

    comparing a constant current ($I_{qse}$) of a three-phase-to-two-phase converter (17) of an output port of a BLDC motor (16) to a reference current ($I_{std}$) of a present air flow mode; **characterised in that**
    as a result of the comparison, applying speed command ($\omega^*_m$) to a rotational speed control unit (10); and
    controlling, by the rotational speed control unit (10), a speed of the BLDC motor (16) according to the applied speed commands ($\omega^*_m$),
    wherein as the result of the comparison, applying an increase speed command ($\omega^*_m$) to a rotational speed control unit (10) when the constant current ($I_{qse}$) is lower than the reference current ($I_{std}$), applying a decrease speed command ($\omega^*_m$) to the rotational speed control unit (10) when the constant current ($I_{qse}$) is higher than the reference current ($I_{std}$), and maintaining and applying the same speed command ($\omega^*_m$) to the rotational speed control unit (10) when the constant current ($I_{qse}$) is the same as the reference current ($I_{std}$).

2. The method of claim 1, wherein the reference current ($I_{std}$) has a preset value corresponding to a respec-

tive mode of a multi-stage airflow.

**3.** The method of claim 1 or claim 2, wherein the speed commands ($\omega^*_m$) are applied to the rotational speed control unit (10) after a present speed ($\omega_m$) of the BLDC motor (16) is fed back thereto.

**4.** The method of any one of claim 1 to claim 3, wherein:

the rotational speed control unit (10) includes a speed controller (11) and a current controller (12);
the speed command is applied to the speed controller (11); and
the speed controller (11) applies a current command ($I^*_{qse}$) corresponding to the applied speed command ($\omega^*_m$) to the current controller (12).

**5.** The method of claim 4, wherein the current command ($I^*_{qse}$) is applied to the current controller (12) after the constant current ($I_{qse}$) of the three-phase-to-two-phase converter (17) of the output port of the BLDC motor (16) is fed back thereto.

**6.** The method of any one of claim 1 to 5, in a process of entering a higher speed airflow mode than the present airflow mode, the method further comprising:

obtaining an instant speed of the BLDC motor (16) at a time point at which the constant current ($I_{qse}$) of the three-phase-to-two-phase converter (17) of the output port of the BLDC motor (16) exceeds an entering reference current of a corresponding airflow mode; and
applying the obtained instant speed to the rotational speed control unit (10) as a temporary speed command ($\omega^{**}_m$) and completing a process of entering the corresponding airflow mode.

**7.** The method of claim 6, wherein the entering reference current has a higher value than a preset reference current of the corresponding airflow mode.

**8.** The method of any one of claims 1 to 7, wherein the instant speed of the BLDC motor (16) is obtained using a sensorless method.

**9.** A controller of a BLDC motor comprising a BLDC motor (16), and a rotational speed control unit (10) including a speed controller (11) configured to generate a current command ($I^*_{qse}$) for controlling a rotational speed of the BLDC motor,

wherein the controller of a BLDC motor (16) further comprises a constant current control unit (20) configured to receive a constant current ($I_{qse}$) of the three-phase-to-two-phase converter (17) of an output port of the BLDC motor (16) as an input, to compare the constant current ($I_{qse}$) to a reference current ($I_{std}$),
**characterised in that**
the constant current control unit (20) is further configured
to output a speed command ($\omega^*_m$) to the rotational speed control unit (10),
wherein the constant current control unit (20) outputs an increase speed command ($\omega^*_m$) when the constant current ($I_{qse}$) is lower than the reference current, outputs a decrease speed command ($\omega^*_m$) when the constant current ($I_{qse}$) is higher than the reference current, and maintains and outputs the same speed command ($\omega^*_m$) when the constant current ($I_{qse}$) is the same as the reference current.

**10.** The controller of the BLDC motor of claim 9, wherein a command in which the present speed ($\omega_m$) of the BLDC motor (16) is fed back to the speed command ($\omega^*_m$) output from the constant current control unit (20) is input to the speed controller (11).

**11.** The controller of the BLDC motor of claim 9 or 10, further comprising a motor sensing unit (18) configured to receive a voltage and/or current of an input end of the BLDC motor (16) and a voltage and/or current of the output port of the BLDC motor (16) and output values of a current rotational angular position ($\theta_m$) and a current rotational speed ($\omega_m$) of the BLDC motor,
wherein the rotational speed ($\omega_m$) output from the motor sensing unit (18) is fed back to the speed command output ($\omega^*_m$) from the constant current control unit (20).

**12.** The controller of the BLDC motor of any one of claims 9 to 11, wherein:

the rotational speed control unit (10) further includes a current controller (12); and
the current command ($I^*_{qse}$) is applied to the current controller (12).

**13.** The controller of the BLDC motor of claim 12, wherein the current command is applied to the current controller (12) after the constant current ($I_{qse}$) of the three-phase-to-two-phase converter (17) of the output port of the BLDC motor (16) is fed back thereto.

**14.** The controller as claimed in any one of the claims 9-13 and controlled by a method as claimed in any one of claims 1-8.

**15.** Range hood comprising a fan being driven by a BLDC motor (16) controlled by a controller as claimed in any one of the claims 9-13 and controlled by a method as claimed in any one of the claims 1-8.

**Patentansprüche**

1. Verfahren zum Steuern eines bürstenlosen Gleichstrommotors, BLDC-Motors, wobei das Verfahren Folgendes umfasst:

   Vergleichen eines konstanten Stroms ($I_{qse}$) eines Drei-Phasen/Zwei-Phasen-Umsetzers (17) eines Ausgangsanschlusses eines BLDC-Motors (16) mit einem Referenzstrom ($I_{std}$) einer aktuellen Luftstrombetriebsart;
   **gekennzeichnet durch**
   Eingeben eines Drehzahlbefehls ($\omega^*_m$) in eine Drehzahlsteuereinheit (10) als ein Ergebnis des Vergleichs; und
   Steuern einer Drehzahl des BLDC-Motors (16) gemäß den eingegebenen Drehzahlbefehlen ($\omega^*_m$) durch die Drehzahlsteuereinheit (10),
   wobei als das Ergebnis des Vergleichs ein Drehzahlerhöhungsbefehl ($\omega^*_m$) in eine Drehzahlsteuereinheit (10) eingegeben wird, ein Drehzahlabsenkungsbefehl ($\omega^*_m$) in die Drehzahlsteuereinheit (10) eingegeben wird, wenn der konstante Strom ($I_{qse}$) höher als der Referenzstrom ($I_{std}$) ist, und derselbe Drehzahlbefehl ($\omega^*_m$) beibehalten und in die Drehzahlsteuereinheit (10) eingegeben wird, wenn der konstante Strom ($I_{qse}$) gleich dem Referenzstrom ($I_{std}$) ist.

2. Verfahren nach Anspruch 1, wobei der Referenzstrom ($I_{std}$) einen vorgegebenen Wert aufweist, der einer jeweiligen Betriebsart eines mehrstufigen Luftstroms entspricht.

3. Verfahren nach Anspruch 1 oder Anspruch 2, wobei die Drehzahlbefehle ($\omega^*_m$) in die Drehzahlsteuereinheit (10) eingegeben werden, nachdem eine vorgegebene Drehzahl ($\omega_m$) des BLDC-Motors (16) zu ihr rückgekoppelt worden ist.

4. Verfahren nach einem der Ansprüche von Anspruch 1 bis Anspruch 3, wobei:

   die Drehzahlsteuereinheit (10) eine Drehzahlsteuereinrichtung (11) und eine Stromsteuereinrichtung (12) enthält;
   der Drehzahlbefehl in die Drehzahlsteuereinrichtung (11) eingegeben wird; und
   die Drehzahlsteuereinrichtung (11) einen Strombefehl ($I^*_{qse}$), der dem eingegebenen Drehzahlbefehl ($\omega^*_m$) entspricht, in die Stromsteuereinrichtung(12) eingibt.

5. Verfahren nach Anspruch 4, wobei der Strombefehl ($I^*_{qse}$) in die Stromsteuereinrichtung (12) eingegeben wird, nachdem der konstante Strom ($I_{qse}$) des Drei-Phasen/Zwei-Phasen-Umsetzers (17) des Ausgangsanschlusses des BLDC-Motors (16) zu ihr rückgekoppelt worden ist.

6. Verfahren nach einem der Ansprüche 1 bis 5 in einem Prozess des Eintretens in eine Luftstrombetriebsart mit höherer Drehzahl als jene der aktuellen Luftstrombetriebsart, wobei das Verfahren ferner Folgendes umfasst:

   Erhalten einer momentanen Drehzahl des BLDC-Motors (16) zu einem Zeitpunkt, zu dem der konstante Strom ($I_{qse}$) des Drei-Phasen/Zwei-Phasen-Umsetzers (17) des Ausgangsanschlusses des BLDC-Motors (16) einen Referenzeintrittsstrom einer entsprechenden Luftstrombetriebsart überschreitet; und
   Eingeben der erhaltenen, momentanen Drehzahl in die Drehzahlsteuereinheit (10) als einen vorübergehenden Drehzahlbefehl ($\omega^{**}_m$) und Abschließen des Prozesses des Eintretens in die entsprechende Luftstrombetriebsart.

7. Verfahren nach Anspruch 6, wobei der Referenzeintrittsstrom einen höheren Wert als ein vorgegebener Referenzstrom der entsprechenden Luftstrombetriebsart aufweist.

8. Verfahren nach einem der Ansprüche 1 bis 7, wobei die momentane Drehzahl des BLDC-Motors (16) unter Verwendung eines sensorfreien Verfahrens erhalten wird.

9. Steuereinrichtung eines BLDC-Motors, die einen BLDC-Motor (16) und eine Drehzahlsteuereinheit (10), die eine Drehzahlsteuereinrichtung (11) enthält, die konfiguriert ist, einen Strombefehl ($I^*_{qse}$) zum Steuern einer Drehzahl des BLDC-Motors zu erzeugen, umfasst,

   wobei die Steuereinrichtung eines BLDC-Motors (16) ferner eine Konstantstrom-Steuereinheit (20) umfasst, die konfiguriert ist, einen konstanten Strom ($I_{qse}$) des Drei-Phasen/Zwei-Phasen-Umsetzers (17) eines Ausgangsanschlusses des BLDC-Motors (16) als einen Eingang zu empfangen, um den konstanten Strom ($I_{qse}$) mit einem Referenzstrom ($I_{std}$) zu vergleichen,
   **dadurch gekennzeichnet, dass**
   die Konstantstrom-Steuereinheit (20) ferner konfiguriert ist, einen Drehzahlbefehl ($\omega^*_m$) an die Drehzahlsteuereinheit (10) auszugeben,
   wobei die Konstantstrom-Steuereinheit (20) einen Drehzahlerhöhungsbefehl ($\omega^*_m$) ausgibt, wenn der konstante Strom ($I_{qse}$) niedriger als der Referenzstrom ist, einen Drehzahlabsen-

kungsbefehl ($\omega^*_m$) ausgibt, wenn der konstante Strom ($I_{qse}$) höher als der Referenzstrom ist, und denselben Drehzahlbefehl ($\omega^*_m$) beibehält und ausgibt, wenn der konstante Strom ($I_{qse}$) gleich dem Referenzstrom ist.

**10.** Steuereinrichtung des BLDC-Motors nach Anspruch 9, wobei ein Befehl, in dem die aktuelle Drehzahl ($\omega_m$) des BLDC-Motors (16) auf den Drehzahlbefehl ($\omega^*_m$), der von der Konstantstrom-Steuereinheit (20) ausgegeben wird, rückgekoppelt wird, in die Drehzahlsteuereinrichtung (11) eingegeben wird.

**11.** Steuereinrichtung des BLDC-Motors nach Anspruch 9 oder 10, die ferner eine Motorerfassungseinheit (18) umfasst, die konfiguriert ist, eine Spannung und/oder einen Strom von einem Eingangsende des BLDC-Motors (16) und eine Spannung und/oder einen Strom vom Ausgangsanschluss des BLDC-Motors (16) und Ausgangswerte einer aktuellen Drehwinkelposition ($\theta_m$) und einer aktuellen Drehzahl ($\omega_m$) des BLDC-Motors zu empfangen,
wobei die Drehzahl ($\omega_m$), die von der Motorerfassungseinheit (18) ausgegeben wird, zu dem Drehzahlbefehlsausgang ($\omega^*_m$) von der Konstantstrom-Steuereinheit (20) rückgekoppelt wird.

**12.** Steuereinrichtung des BLDC-Motors nach einem der Ansprüche 9 bis 11, wobei:

die Drehzahlsteuereinheit (10) ferner eine Stromsteuereinrichtung (12) enthält; und
der Strombefehl ($I^*_{qse}$) in die Stromsteuereinrichtung (12) eingegeben wird.

**13.** Steuereinrichtung des BLDC-Motors nach Anspruch 12, wobei der Strombefehl in die Stromsteuereinrichtung (12) eingegeben wird, nachdem der konstante Strom ($I_{qse}$) des Drei-Phasen/Zwei-Phasen-Umsetzers (17) des Ausgangsanschlusses des BLDC-Motors (16) zu ihr rückgekoppelt worden ist.

**14.** Steuereinrichtung nach einem der Ansprüche 9-13, die durch ein Verfahren nach einem der Ansprüche 1-8 gesteuert wird.

**15.** Dunstabzugshaube, die einen Lüfter umfasst, der durch einen BLDC-Motor (16) angetrieben wird, der durch eine Steuereinrichtung nach einem der Ansprüche 9-13 gesteuert wird und durch ein Verfahren nach einem der Ansprüche 1-8 gesteuert wird.

## Revendications

**1.** Procédé de commande d'un moteur à courant continu sans balai, BLDC, le procédé comportant l'étape consistant à :

comparer un courant constant ($I_{qse}$) d'un convertisseur triphasé en biphasé (17) d'un port de sortie d'un moteur BLDC (16) en un courant de référence ($I_{std}$) d'un mode d'écoulement d'air actuel ;
**caractérisé par** les étapes consistant à :

en résultat de la comparaison, appliquer une instruction de vitesse ($\omega^*_m$) à une unité de commande de vitesse de rotation (10) ; et
commander, par l'unité de commande de vitesse de rotation (10), une vitesse du moteur BLDC (16) en fonction des instructions de vitesse ($\omega^*_m$) appliquées,
dans lequel en résultat de la comparaison, appliquer une instruction d'augmentation de vitesse ($\omega^*_m$) à une unité de commande de vitesse de rotation (10) lorsque le courant constant ($I_{qse}$) est inférieur au courant de référence ($I_{std}$), appliquer une instruction de réduction de vitesse ($\omega^*_m$) à l'unité de commande de vitesse de rotation (10) lorsque le courant constant ($I_{qse}$) est supérieur au courant de référence ($I_{std}$), et maintenir et appliquer la même instruction de vitesse ($\omega^*_m$) à l'unité de commande de vitesse de rotation (10) lorsque le courant constant ($I_{qse}$) est le même que le courant de référence ($I_{std}$).

**2.** Procédé selon la revendication 1, dans lequel le courant de référence ($I_{std}$) a une valeur préréglée correspondant à un mode respectif d'un écoulement d'air à étages multiples.

**3.** Procédé selon la revendication 1 ou la revendication 2, dans lequel les instructions de vitesse ($\omega^*_m$) sont appliquées à l'unité de commande de vitesse de rotation (10) après qu'une vitesse actuelle ($\omega_m$) du moteur BLDC (16) est réinjectée dans celle-ci.

**4.** Procédé selon l'une quelconque des revendications 1 à 3, dans lequel :

l'unité de commande de vitesse de rotation (10) inclut une commande de vitesse (11) et une commande de courant (12) ;
l'instruction de vitesse est appliquée à la commande de vitesse (11) ; et
la commande de vitesse (11) applique une instruction de courant ($I^*_{qse}$) correspondant à l'instruction de vitesse ($\omega^*_m$) appliquée, à la commande de courant (12).

**5.** Procédé selon la revendication 4, dans lequel l'instruction de courant ($I^*_{qse}$) est appliquée à la commande de courant (12) après que le courant constant

($I_{qse}$) du convertisseur triphasé en biphasé (17) du port de sortie du moteur BLDC (16) est réinjecté dans celle-ci.

**6.** Procédé selon l'une quelconque des revendications 1 à 5, dans un processus d'entrée dans un mode d'écoulement d'air à vitesse plus élevée que le mode d'écoulement d'air actuel, le procédé comportant en outre les étapes consistant à :

obtenir une vitesse instantanée du moteur BLDC (16) à un instant auquel le courant constant ($I_{qse}$) du convertisseur triphasé en biphasé (17) du port de sortie du moteur BLDC (16) dépasse un courant de référence entrant d'un mode d'écoulement d'air correspondant ; et
appliquer la vitesse instantanée obtenue à l'unité de commande de vitesse de rotation (10) comme une instruction de vitesse temporaire ($\omega^{**}_m$) et mettre fin à un processus d'entrée dans le mode d'écoulement d'air correspondant.

**7.** Procédé selon la revendication 6, dans lequel le courant de référence entrant a une valeur plus élevée qu'un courant de référence préréglé du mode d'écoulement d'air correspondant.

**8.** Procédé selon l'une quelconque des revendications 1 à 7, dans lequel la vitesse instantanée du moteur BLDC (16) est obtenue en utilisant un procédé sans capteur.

**9.** Commande d'un moteur BLDC comportant un moteur BLDC (16), et une unité de commande de vitesse de rotation (10) incluant une commande de vitesse (11) configurée pour générer une instruction de courant ($I^*_{qse}$) pour commander une vitesse de rotation du moteur BLDC,

dans laquelle la commande d'un moteur BLDC (16) comporte en outre une unité de commande de courant constant (20) configurée pour recevoir un courant constant ($I_{qse}$) du convertisseur triphasé en biphasé (17) d'un port de sortie du moteur BDLC (16) en tant qu'entrée, pour comparer le courant constant ($I_{qse}$) à un courant de référence ($I_{std}$),
**caractérisée en ce que**
l'unité de commande de courant constant (20) est en outre configurée pour transmettre une instruction de vitesse ($\omega^*_m$) à l'unité de commande de vitesse de rotation (10),
dans laquelle l'unité de commande de courant constant (20) transmet une instruction d'augmentation de vitesse ($\omega^*_m$) lorsque le courant constant ($I_{qse}$) est inférieur au courant de référence, transmet une instruction de réduction de vitesse ($\omega^*_m$) lorsque le courant constant ($I_{qse}$) est supérieur au courant de référence, et maintient et transmet la même instruction de vitesse ($\omega^*_m$) lorsque le courant constant ($I_{qse}$) est le même que le courant de référence.

**10.** Commande du moteur BLDC selon la revendication 9, dans lequel une instruction dans laquelle la vitesse actuelle ($\omega_m$) du moteur BLDC (16) est réinjectée dans l'instruction de vitesse ($\omega^*_m$) transmise à partir de l'unité de commande de courant constant (20), est appliquée à l'entrée de la commande de vitesse (11).

**11.** Commande du moteur BLDC selon la revendication 9 ou 10, comportant en outre une unité de détection de moteur (18) configurée pour recevoir une tension et/ou un courant d'une extrémité d'entrée du moteur BLDC (16) et une tension et/ou un courant du port de sortie du moteur BLDC (16) et transmet des valeurs d'une position angulaire de rotation actuelle ($\theta_m$) et d'une vitesse de rotation actuelle ($\omega_m$) du moteur BDLC,
dans laquelle la vitesse de rotation ($\omega_m$) transmise à partir de l'unité de détection de moteur (18) est réinjectée dans l'instruction de vitesse ($\omega^*_m$) transmise à partir de l'unité de commande de courant constant (20).

**12.** Commande du moteur BDLC selon l'une quelconque des revendications 9 à 11, dans laquelle :

l'unité de commande de vitesse de rotation (10) inclut en outre une commande de courant (12) ; et
l'instruction de courant ($I^*_{qse}$) est appliquée à la commande de courant (12).

**13.** Commande du moteur BDLC selon la revendication 12, dans laquelle l'instruction de courant est appliquée à la commande de courant (12) après que le courant constant ($I_{qse}$) du convertisseur triphasé en biphasé (17) du port de sortie du moteur BLDC (16) est réinjecté dans celle-ci.

**14.** Commande selon l'une quelconque des revendications 9 à 13 et commandée par un procédé selon l'une quelconque des revendications 1 à 8.

**15.** Hotte de cuisine comportant un ventilateur entraîné par un moteur BLDC (16) commandé par une commande selon l'une quelconque des revendications 9 à 13 et commandé par un procédé selon l'une quelconque des revendications 1 à 8.

FIG. 1

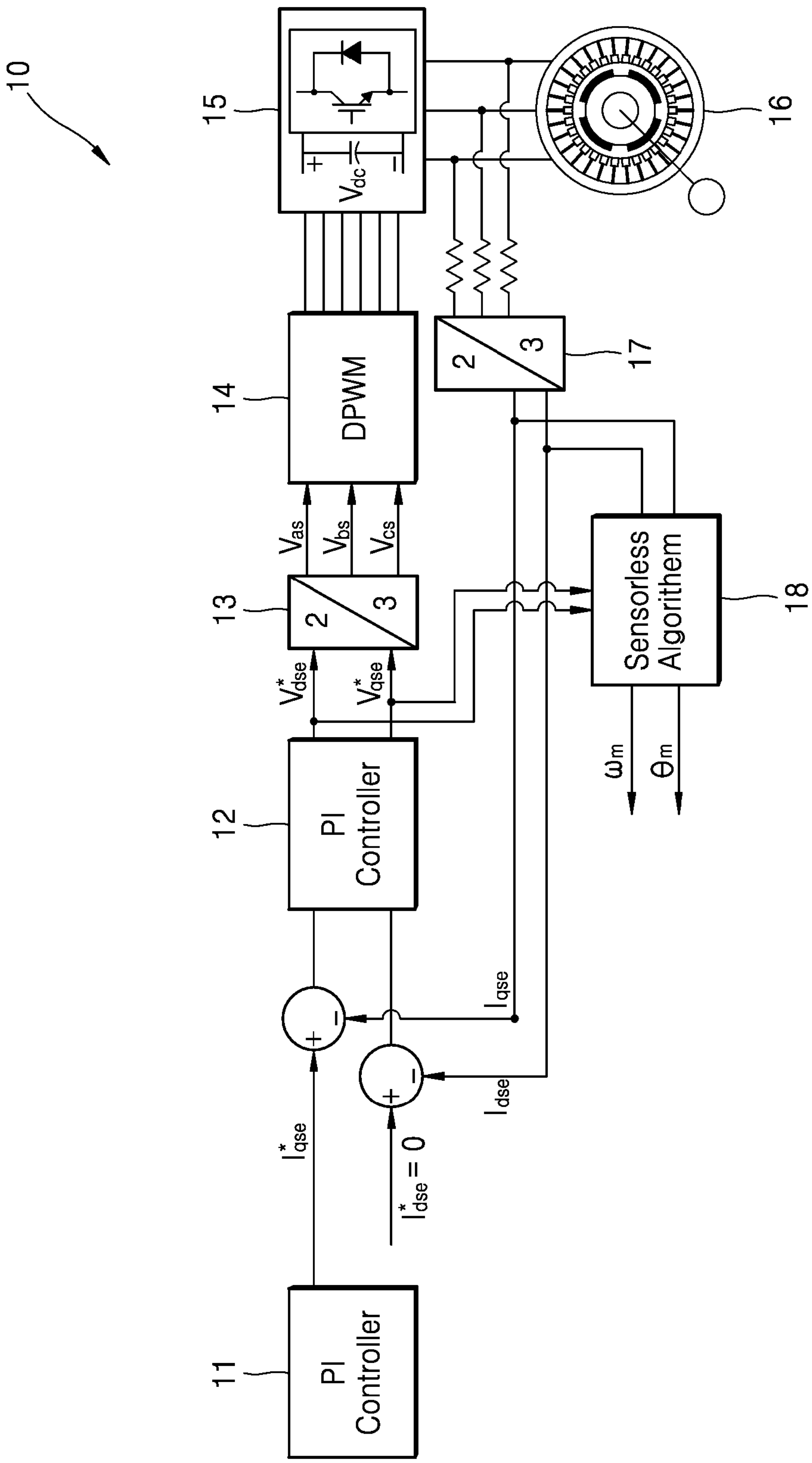
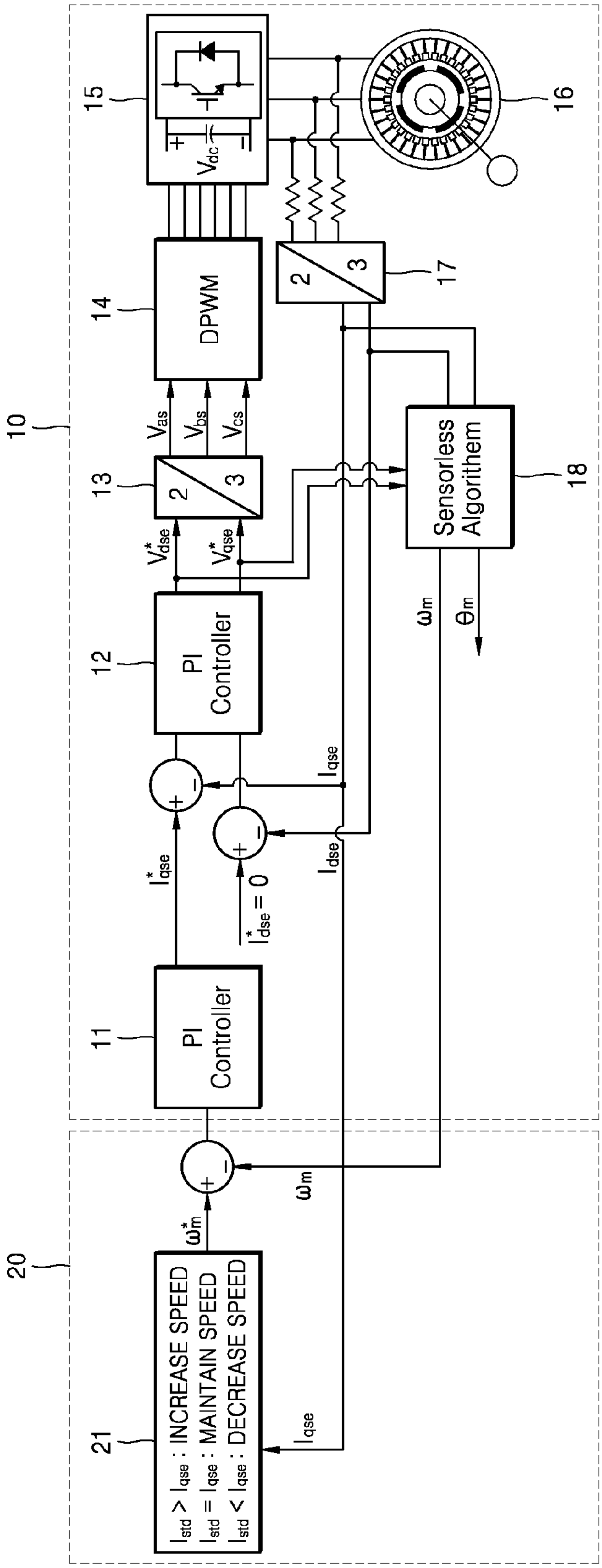

10
11
PI Controller
12
PI Controller
13
2
3
14
DPWM
15
$V_{dc}$
16
17
2
3
18
Sensorless Algorithem
$I^*_{qse}$
$I^*_{dse} = 0$
$I_{qse}$
$I_{dse}$
$V^*_{dse}$
$V^*_{qse}$
$V_{as}$
$V_{bs}$
$V_{cs}$
$\omega_m$
$\theta_m$

FIG. 2


10
11
PI Controller
12
PI Controller
13
2
3
14
DPWM
15
Vdc
16
17
2
3
18
Sensorless Algorithem
20
21
Istd > Iqse : INCREASE SPEED
Istd = Iqse : MAINTAIN SPEED
Istd < Iqse : DECREASE SPEED
ω*m
ωm
θm
I*qse
I*dse = 0
Iqse
Idse
V*dse
V*qse
Vas
Vbs
Vcs

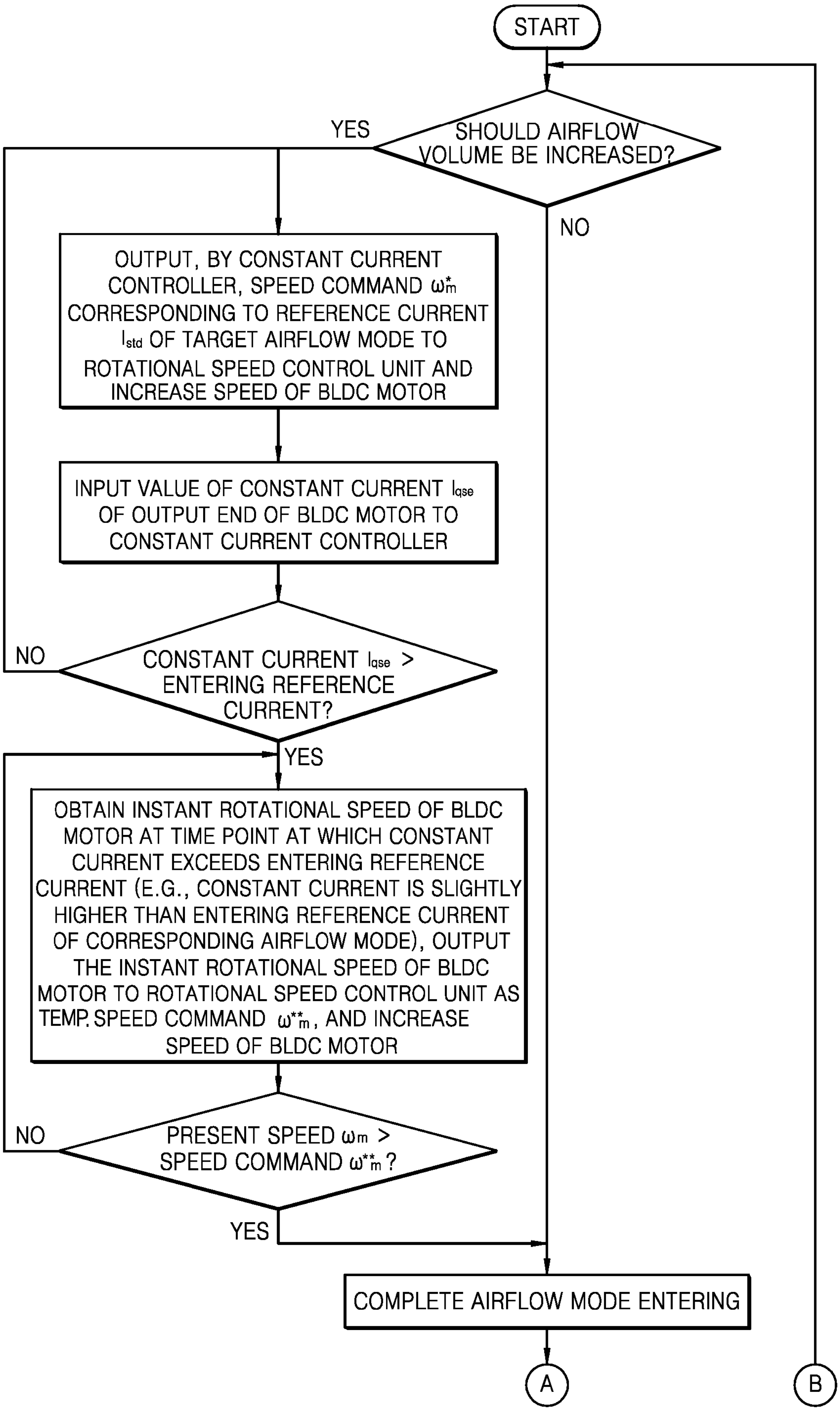

START
SHOULD AIRFLOW VOLUME BE INCREASED?
YES
NO
OUTPUT, BY CONSTANT CURRENT CONTROLLER, SPEED COMMAND ω*m CORRESPONDING TO REFERENCE CURRENT Istd OF TARGET AIRFLOW MODE TO ROTATIONAL SPEED CONTROL UNIT AND INCREASE SPEED OF BLDC MOTOR
INPUT VALUE OF CONSTANT CURRENT Iqse OF OUTPUT END OF BLDC MOTOR TO CONSTANT CURRENT CONTROLLER
CONSTANT CURRENT Iqse > ENTERING REFERENCE CURRENT?
NO
YES
OBTAIN INSTANT ROTATIONAL SPEED OF BLDC MOTOR AT TIME POINT AT WHICH CONSTANT CURRENT EXCEEDS ENTERING REFERENCE CURRENT (E.G., CONSTANT CURRENT IS SLIGHTLY HIGHER THAN ENTERING REFERENCE CURRENT OF CORRESPONDING AIRFLOW MODE), OUTPUT THE INSTANT ROTATIONAL SPEED OF BLDC MOTOR TO ROTATIONAL SPEED CONTROL UNIT AS TEMP. SPEED COMMAND ω**m, AND INCREASE SPEED OF BLDC MOTOR
PRESENT SPEED ωm > SPEED COMMAND ω**m ?
NO
YES
COMPLETE AIRFLOW MODE ENTERING
A
B

Fig. 3

FIG. 4

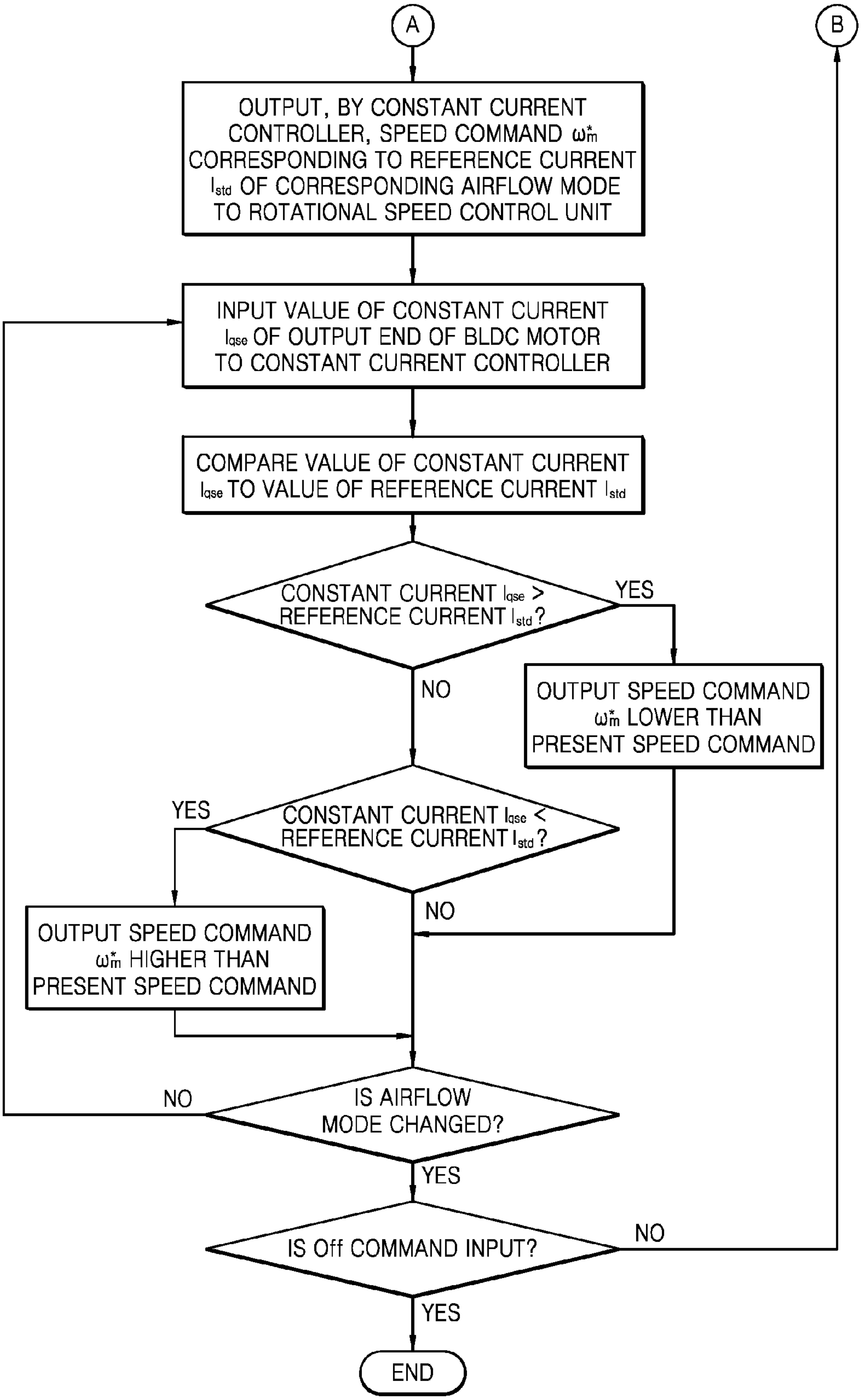
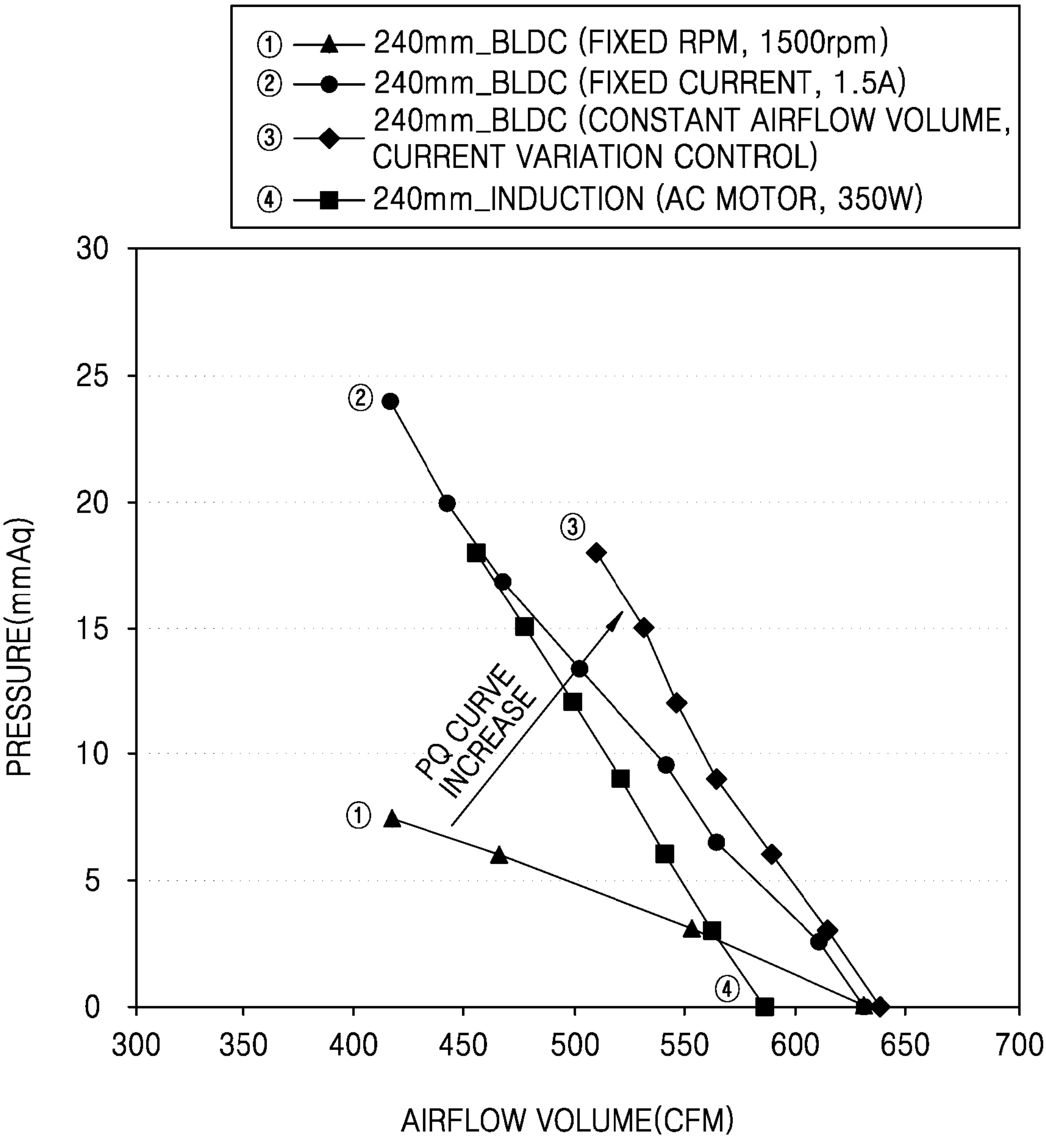

A
B
OUTPUT, BY CONSTANT CURRENT CONTROLLER, SPEED COMMAND ω*m CORRESPONDING TO REFERENCE CURRENT Istd OF CORRESPONDING AIRFLOW MODE TO ROTATIONAL SPEED CONTROL UNIT
INPUT VALUE OF CONSTANT CURRENT Iqse OF OUTPUT END OF BLDC MOTOR TO CONSTANT CURRENT CONTROLLER
COMPARE VALUE OF CONSTANT CURRENT Iqse TO VALUE OF REFERENCE CURRENT Istd
CONSTANT CURRENT Iqse > REFERENCE CURRENT Istd?
YES
OUTPUT SPEED COMMAND ω*m LOWER THAN PRESENT SPEED COMMAND
NO
YES
CONSTANT CURRENT Iqse < REFERENCE CURRENT Istd?
OUTPUT SPEED COMMAND ω*m HIGHER THAN PRESENT SPEED COMMAND
NO
NO
IS AIRFLOW MODE CHANGED?
YES
IS Off COMMAND INPUT?
NO
YES
END

FIG. 5


① 240mm_BLDC (FIXED RPM, 1500rpm)
② 240mm_BLDC (FIXED CURRENT, 1.5A)
③ 240mm_BLDC (CONSTANT AIRFLOW VOLUME, CURRENT VARIATION CONTROL)
④ 240mm_INDUCTION (AC MOTOR, 350W)
PRESSURE(mmAq)
30
25
20
15
10
5
0
PQ CURVE INCREASE
①
②
③
④
300
350
400
450
500
550
600
650
700
AIRFLOW VOLUME(CFM)

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description

- CN 103123124 A **[0012]**